DEPARTMENT OF THE AIR FORCE
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH (AFMC)
BOLLING AIR FORCE BASE, DC

OFFICE OF THE
DIRECTOR

9 MAR 98

Dear Reader

Welcome to the first issue of AFOSR's revised *Research Highlights*. Our newly designed publication profiles innovative basic research performed by AFOSR-sponsored scientists. Every two months, we will highlight articles that report on the accomplishments emerging from fundamental inquiry, ideas, processes, and innovations. This research, which may lead to technological breakthroughs in support of the Air Force mission, may prove beneficial to the public and private sector as well.

Our articles will focus on basic research programs and highlight technology transitions and transfers. Additionally, we will address programs and partnerships that AFOSR has created in government, academia and business. These partnerships bring together some of the most brilliant and creative scientific minds in the U.S. and abroad. Many AFOSR-sponsored researchers have received widespread peer recognition for their accomplishments and have accumulated prestigious awards including the Nobel Prize. *Research Highlights* will bring you news of their many accomplishments.

We hope you find our publication informative. The research you see highlighted today will contribute to the high-tech systems and scientific breakthroughs of tomorrow. We would be pleased to hear from you regarding your ideas, comments, and suggestions.

Sincerely

Joseph F Janni

JOSEPH F. JANNI
Director

Attachment:
*Research HIGHLIGHTS, JAN/FEB 98*

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH [AFOSR]

# Research HIGHLIGHTS

JAN FEB 98





## NEW SEMICONDUCTOR TECHNOLOGY

# Ground-, Space-Based Systems Will Exchange More Information Faster

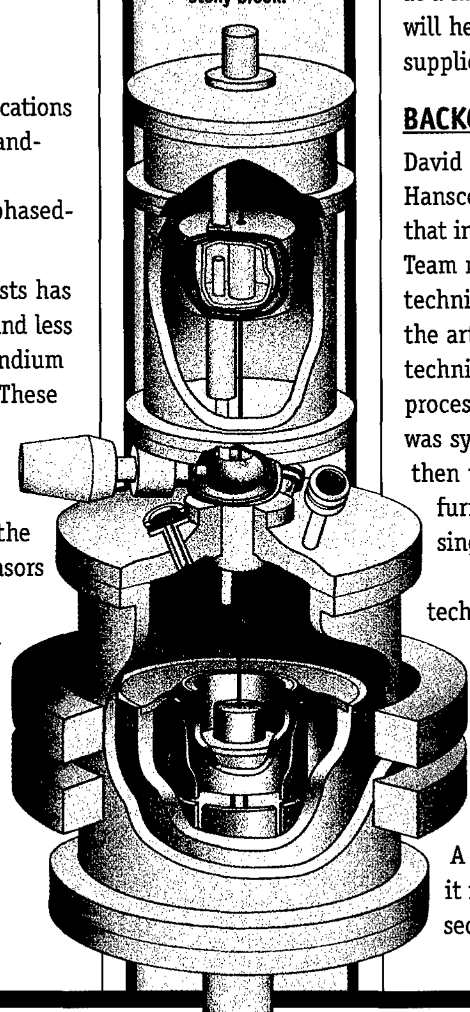
AFOSR basic research advances in semiconductor technology and their technology transfer to industry is offering handsome payoffs for many Air Force applications. Most importantly, ground- and space-based systems will soon be able to exchange more information using:

- Eye-safe lasers for free-space optical communication systems;
- Wireless Radio Frequency (RF) communications with significantly higher speed and bandwidth; and,
- High-speed, electronically steerable, phased-array antennas.

A team of AFOSR-sponsored scientists has developed an innovative, more efficient, and less costly process for growing high-quality Indium Phosphide (InP) semiconductor crystals. These crystals form the basis for fabricating wafers used in creating optoelectronics and radio frequency electronics. The research team includes researchers from the Air Force Research Laboratory (AFRL) Sensors Directorate facility at Hanscom Air Force Base, Mass., a consortium of universities, and a small business specializing in crystal growth technology.

InP-based electronic components perform dramatically better than those made from the traditional Gallium Arsenide or Silicon, because InP can operate at higher frequencies. Japanese industry uses the state-of-the-art InP manufacturing process to synthesize expensive, standard two-inch wafers, and three-inch wafers at a premium price. With technology transfer from AFOSR, U.S. industry can use the new growth process to create InP wafers four times the area of the standard two-inch wafer at a much lower cost. Use of the new process will help U.S. industry become a leading supplier of InP substrate.

Schematic diagram of high pressure InP "crystal puller" manufactured by GT Equipment Technologies, Inc. under the guidance of computer modeling developed by SUNY Stony Brook.



## BACKGROUND

David Bliss, an AFRL materials scientist at Hanscom AFB, led the AFRL/SNH research team that invented the core crystal growth technology. Team members developed two interrelated techniques that advance the current state of the art in commercial InP production. Their techniques improve the established two-step process where polycrystalline InP raw material was synthesized in one high pressure chamber, then transferred to and re-melted in a second furnace for subsequent "pulling" of a new single-crystal ingot from a melt.

The first new Air Force-patented technique involves a one-step process that eliminates the costly transfer step, as well as possible contamination. Phosphorous is injected into melted indium to convert it to molten InP. Then an InP seed crystal is then lowered into the melt to begin growing the new crystal. A crystal ingot then grows from the seed as it is slowly pulled from the melt. In the second innovation, the researchers applied a

continued on page 2...

magnetic field to stabilize the melt to grow a flat-topped ingot rather than the industry standard cone-topped ingot. This minimizes wasted material when the ingot is sliced into wafers.

## PARTNERSHIPS

This innovative InP manufacturing process emerged from partnerships among AFRL, university and private industry scientists. To make the technology's growth more efficient and reproducible, the Sensors Directorate researchers collaborated with State University of New York (SUNY)- Stony Brook's Center for Crystal Growth under the AFOSR-sponsored Summer Faculty Research Program. A subsequent meeting of the AFOSR Working Group on High-Pressure Crystal Growth at Hanscom AFB in the summer of 1993 contributed to the definition of a Multidisciplinary University Research Initiative (MURI)[1] topic on crystal growth. Professor Vish Prasad at SUNY Stony Brook later organized several research groups for a MURI proposal, which resulted in AFOSR and Defense Advanced Research Prospects Agency (DARPA) sponsorship of an integrated intelligent modeling, design and control program of the crystal growth process.

This process is now being transferred to industry through GT Equipment Technologies, Inc., (GTi) of Nashua, N.H. under the Small Business Technology Transfer (STTR) program. AFRL researchers expect delivery of a prototype commercial InP growth furnace this spring under GTi's Phase II STTR contract.

Developers and manufacturers of Air Force electronic components will soon be able to buy high-quality, lower cost InP wafers manufactured from domestic rather than foreign suppliers as a result of this AFRL, university and industry research effort. The Air Force benefits with ground- and space-based systems exchanging information at much faster rates than previously possible.

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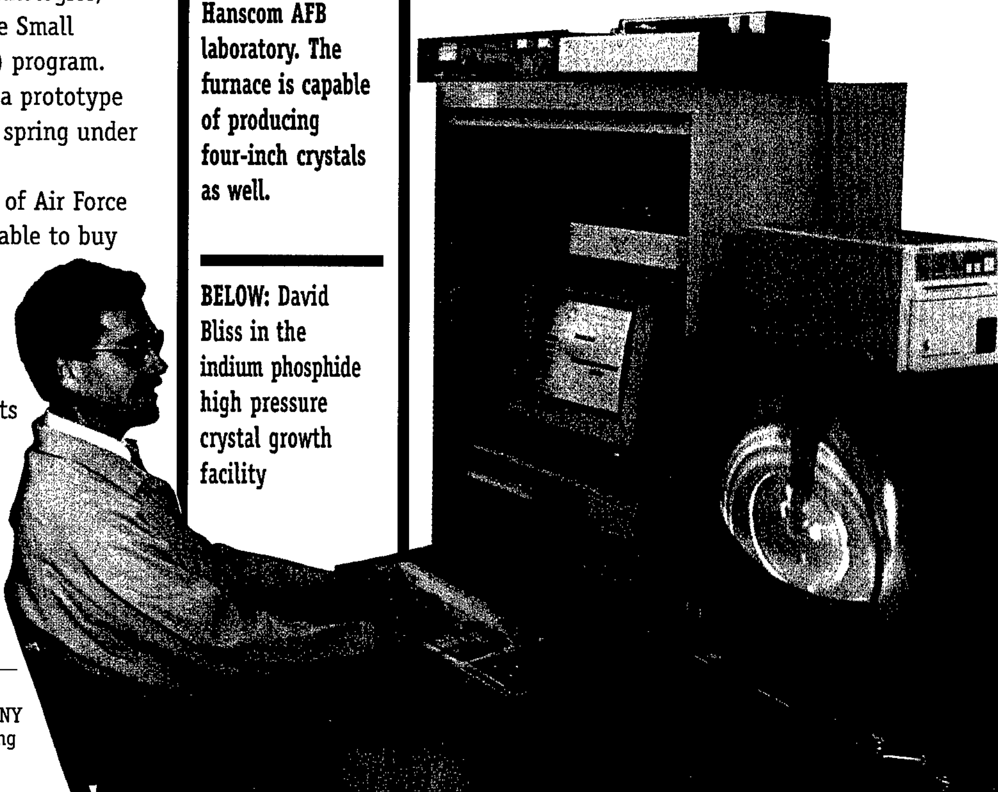
**RIGHT: Three InP crystal ingots grown in the AFRL Sensors Directorate's one-step, high-pressure MLEK crystal growth furnace. The wafer shown at the lower right corner of the photo is a state-of-the-art, two-inch InP substrate sliced from an ingot grown at the AFRL/SN Hanscom AFB laboratory. The furnace is capable of producing four-inch crystals as well.**

**BELOW: David Bliss in the indium phosphide high pressure crystal growth facility**



**For more information:**

- Growing Indium Phosphide (InP) crystals
- Technology transfer partnerships
- How a basic science idea evolved into a delivered crystal puller

**See our web site at:**

**http://www.afosr.af.mil**

[1] Dr. Marc Jacobs of the Directorate of Mathematics and Geosciences manages SUNY STONY BROOK MURI and the AFOSR Working Group on High-Pressure Crystal Growth.

Research Advances Contribute to Stealth Aircraft Design

# AFOSR PI Wins Esteemed Wolf Foundation Prize for Mathematics

**Dr. Joseph Keller is the Wolf Foundation's 1996-1997 prize-winner in mathematics. The Foundation recognized Dr. Keller for "his profound and innovative contributions, in particular to electromagnetic, optical and acoustic wave propagation and to fluid, solid, quantum and statistical mechanics."**


Dr. Joseph Keller

Dr. Keller concentrates his AFOSR-funded research on wave propagation. In fact, the design of the stealth platforms — particularly the F-117 — is based on his original research on high-frequency electromagnetic scattering. His current research is focused on electromagnetic wave propagation through turbulent media. Turbulence causes local changes in the refractive index of air. Laser wavefronts transmitted through turbulent air become distorted and can be diverted, or break up into several beams. Ameliorating the effects of turbulence will allow accurate targeting by the Airborne Laser.

The Wolf Foundation was established in 1976 by the late Dr. Ricardo Wolf, an inventor, diplomat and philanthropist, and his wife Francisca Subirana-Wolf "to promote science and art for the benefit of mankind." Each year, five or six prizes have been awarded annually to outstanding living scientists and artists "for achievements in the interest of mankind and friendly relations among peoples." Scientific prizes are awarded in the fields of agriculture, chemistry, mathematics, medicine, and physics. In the arts, one prize is awarded annually and is rotated among the categories of architecture, music, painting and sculpture. Every year, committees of international experts in each field are appointed to select the winners. The prize carries a $100,000 stipend for each recipient.

Dr. Keller holds a joint appointment in mathematics and mechanical engineering at Stanford University and is a member of the United States National Academy of Sciences. His other honors include the National Medal of Science which he received during White House ceremonies in 1988.

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## New Molecular Design Concept

# Novel Polymeric Material Could Strengthen Performance of Composites, Gaskets

An AFOSR-sponsored researcher has recently discovered an entirely new class of materials that may enable inflatable space-based antenna structures to achieve their desired shape when inflated in space. This will allow advanced communications and surveillance capabilities that are not possible with current space-based antenna structures. The new materials can also be used to design polymeric seals that tighten under pressure and to design composite material systems with improved mechanical strength.

Professor Anselm Griffin, at the University of Southern Mississippi, has recently shown that properly engineered polymeric materials will thicken when stretched instead of getting thinner. This new molecular design concept can be used to solve failure problems in a wide variety of military systems such as loss of seal in high-pressure gaskets in aircraft and rocket engines and weakening of fiber-reinforced composites due to fiber-pull-out under stress. Use of this new class of materials will strengthen structural components used in future aircraft, rocket and satellite systems.


Anselm C. Griffin

## BACKGROUND

Almost all materials will get thinner when stretched. The effect of materials getting thinner when stretched is expressed as a ratio that compares the length of a material by its width when it is stretched. This is typically defined as ***positive*** for normally behaving materials. Professor Griffin's properly engineered polymers can express a ***negative*** ratio. This creates the advantage of developing materials that offer more desired properties, i.e. thickening rather than thinning when stretched.

Professor Griffin is collaborating with Professor Ken Evans at the University of Exeter in the United Kingdom.

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NEXT ISSUE...

## Materials Research Promises Higher Performance Aircraft Engines for Military and Industry

Research conducted at Carnegie Mellon University under a Partnership for Research Excellence and Transition (PRET) shows significant progress toward transitioning a new material for manufacturing future high temperature, gas turbine engines. The new material, titanium aluminide (TiAl) is potentially 60% lighter than currently used nickel-based superalloy components. The reduced weight will translate to savings in fuel consumption.

The PRET, composed of university and industry investigators, provides a unique opportunity for research to be transitioned from university labs to industrial application. In fact, General Electric Aircraft Engines — one of the partners in this consortium — has already included data from this effort in a formal design review.

In our next issue, we'll cover the science of the new material and the transitioning opportunities for industry.

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## Partnership for Research Excellence and Transition (PRET)

The Partnership for Research Excellence and Transition (PRET) program was established by AFOSR in 1995 to support basic research collaboratively between universities and industry that will lead to rapid technology transition. The technology topics focus on Air Force and Department of Defense mission goals. Selected universities are typically funded at $500-$750K per year for five years.

**Research Highlights**

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*Research Highlights* is published every two months by the Air Force Office of Scientific Research. This newsletter provides brief descriptions of AFOSR basic research activities including topics such as research accomplishments, examples of technology transitions and technology transfer, notable peer recognition awards and honors, and other research program achievements. The purpose is to provide Air Force, DoD, government, industry and university communities with brief accounts to illustrate AFOSR support of the Air Force mission.

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